high water on lake winnipeg

the Rocky Mountains; it extends east almost to Lake Superior and as far south as the basin of the Mississippi River. The natural slope of the land to the north of Lake Winnipeg carries runoff directly to the Nelson and Churchill Rivers and to Hudson Bay; very little of this area supplies water to Lake Winnipeg.

From the west, the Saskatchewan River and its two major tributaries, the North Saskatchewan and South Saskatchewan, drain almost the entire Canadian prairie region. The lake-studded area to the east and south of Lake Winnipeg is drained by the Winnipeg River, and from the south the Red River flowing through the city of Winnipeg picks up Assiniboine River water drained from the southern plains of Manitoba and Saskatchewan and empties it into Lake Winnipeg. Numerous smaller rivers make their contribution. These include the Poplar, Berens, Pigeon, Bloodvein and Manigotagan Rivers from the east, the Brokenhead River from the south and the Dauphin River from the west.

By far the greatest contributors to Lake Winnipeg's water supply are the Winnipeg and Saskatchewan Rivers which supply 39 per cent and 32 per cent, respectively. In contrast, the Red River provides only 6 per cent. The remaining 23 per cent is fed by the smaller rivers.

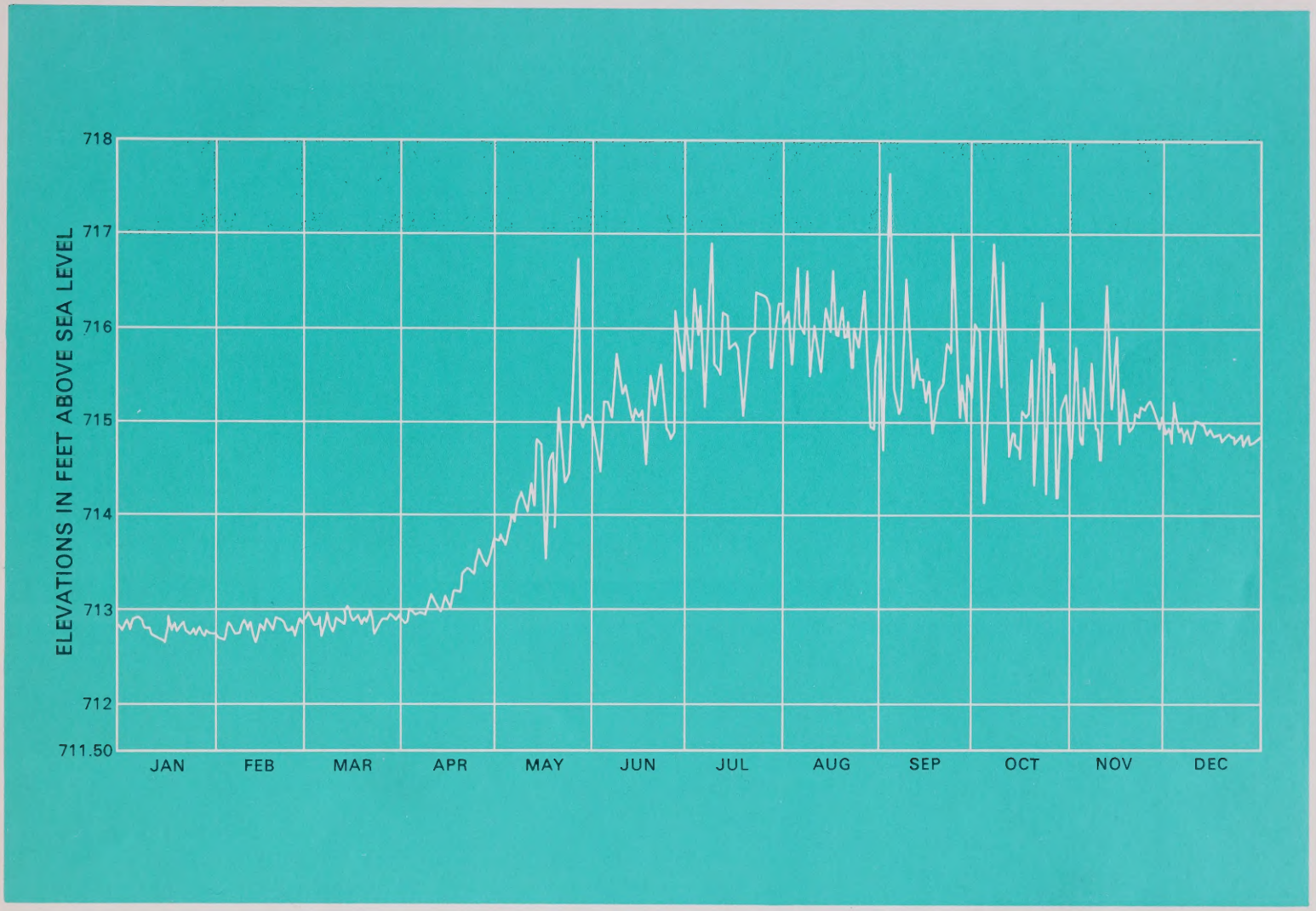
High water on Lake Winnipeg is caused by a complex interplay of natural phenomena

Many natural factors contribute to high water levels on Lake Winnipeg. Most important are the normal seasonal rise in level, the limited carrying capacity of the outlet channel, excessive precipitation on the drainage basin, climatic conditions which affect evaporation and transpiration, carry-over of high water from one year to the next, and wind effect.

Normal seasonal rise in water level: Each year, the level of Lake Winnipeg undergoes normal seasonal variations—rising in the spring when the winter's accumulated snow begins to melt, reaching a peak about mid-summer and gradually declining through the remainder of the year.

The outlet channel: The outlet of Lake Winnipeg is Playgreen Lake, a wide channel about seventy miles long which carries the outflow of Lake Winnipeg to the Nelson River proper and thence to Hudson Bay. Playgreen Lake is shallow and acts as a natural control on the rate of outflow from Lake Winnipeg. When the total flow of the rivers which feed Lake Winnipeg exceeds the outflow from the lake and losses through evaporation from the surface, the level of the lake rises.

Excessive precipitation: The water which finds its way to Lake Winnipeg is collected from all parts of the lake's huge drainage basin and originates as rain or snow. Because of the basin's vast extent, it is possible, and indeed quite usual, to experience above-normal precipitation in one region at the same time as average or below-average precipitation is being experienced in another. The compensating effect of these variations tends to act as a moderating influence on extreme water levels. From time to time, however, conditions of excessive precipitation may be general throughout the entire area of the basin and when this happens, especially



Lake Winnipeg hydrograph shows the seasonal variation in water levels—the spring rise when the snow melts, the mid-summer peak and the gradual decline in the fall and early winter.

if the conditions are prolonged, the amount of water pouring into Lake Winnipeg may be far greater than the amount which can be discharged.

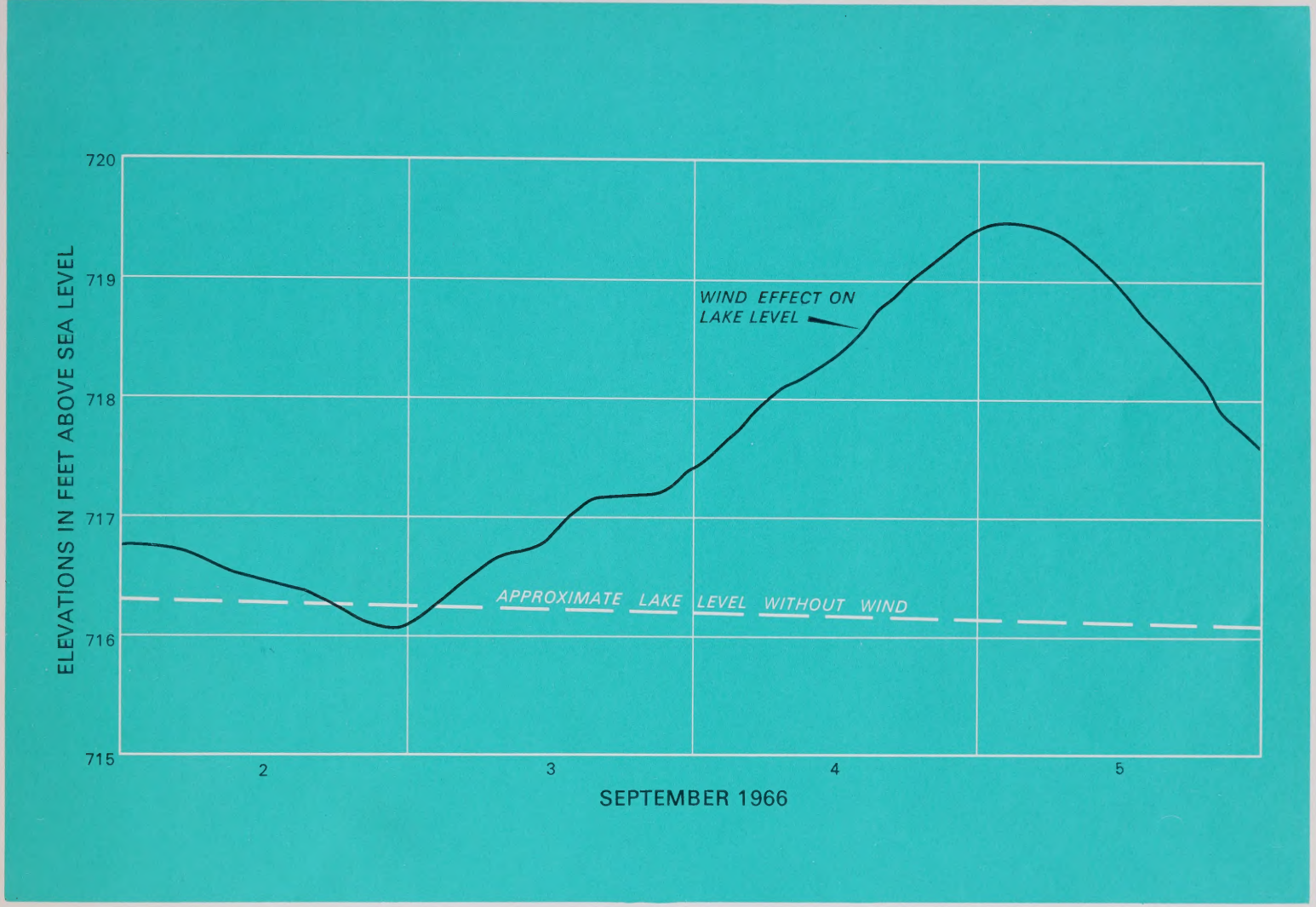
Climatic conditions: An essential element in the circulation of water between earth and atmosphere is the natural phenomenon known as evaporation, a process by which moisture is transferred from a water or soil surface to the atmosphere by vaporization. An associated phenomenon is transpiration, by which moisture is transferred to the atmosphere from the leaf surfaces of plants. The rise in levels in the spring is not moderated appreciably by evaporation, which is low during the spring months. The losses to the atmosphere through high summer evaporation, on the other hand, are substantial and the surface area of Lake Winnipeg and its drainage basin is so large that the loss of water directly to the atmosphere, especially under hot, dry, sunny conditions, can reduce considerably the amount of water that must be discharged by way of the Nelson River. The climatic conditions associated with prolonged heavy precipitation—below-average temperatures, high humidity, overcast skies—are the same conditions that keep evaporation rates at a minimum and reduce the amount of water that can be transferred directly to the atmosphere.

High-water carry-over effect: A heavy inflow of water from the drainage basin causes the level of Lake Winnipeg to rise and the discharge through the outlet channel increases in an attempt to dissipate the high water. But because the rate of discharge is restricted by the carrying capacity of the outlet channel, the lake level may rise to the point where, even though inflow returns to normal, the Nelson River may continue to carry vastly-increased quantities of water from Lake Winnipeg for some considerable time. It is not unusual, in these circumstances, for flood inflows to recur while excess water is still present in the lake. Over a period of years of continuing heavy precipitation, a build-up may occur which will cause unusually high lake levels.

Wind effect: On a large body of water like Lake Winnipeg, the effect of wind can be both remarkable and sudden. A strong northerly wind will pile water at the south end of the lake and increase the level by several feet in a very short period of time. Waves generated by the wind may travel up a sloping beach to reach an even higher level. The magnitude of wind tides depends upon the direction, speed and duration of the wind; wave uprushes are governed by the nature of the shore, the uprush being greatest where the slope of the beach is gentle. When a wind tide occurs at Winnipeg Beach, for example, the chance is greater than one in a hundred that it will amount to $4\frac{1}{2}$ feet; the wave uprush could result in a further 4 feet.

Principal causes of the high water levels of 1966

The factors mainly responsible for the high water levels of Lake Winnipeg in 1966 were precipitation and high-water carry-over. At times, wind effect also contributed.



On a large body of water like Lake Winnipeg, strong winds may pile several feet of water at the downwind end of the lake. On September 5, wind effect added forty-two inches to the water level at Victoria Beach.

In September 1964 the lake level was about six inches above the long-term normal level for September. The melting of an above-normal snowfall followed by above-normal rainfall brought the lake to a fairly high level and in September 1965 the lake was about twenty inches above normal. Carry-over of the high level to 1966 meant that the seasonal rise in levels during the spring and early summer of 1966 started from a higher base. In fact, the high-water carry-over represented about six inches of depth on Lake Winnipeg at the time of maximum high water in 1966.

Above-normal streamflow in rivers feeding Lake Winnipeg raised the lake level about thirty-nine inches above what it would have reached had average streamflow conditions prevailed since September 1965. The Winnipeg River raised the lake level about twenty inches higher than normal; the Red and Saskatchewan Rivers accounted for four and three inches respectively; the other tributary rivers were responsible for the remaining twelve inches.

Added to the higher lake level which resulted from abnormal streamflow was the higher base from which the lake level started its rise in the spring of 1966. In all, therefore, Lake Winnipeg in July 1966 rose to its record level of 717.6 feet, about forty-five inches higher than would have been the case had the inflow been average during 1965 and 1966.

Lake levels, already high, were pushed even higher in some locations by wind effect. On August 1, 1966, the wind piled thirty inches of water on top of the peak level at Matheson Landing and later, during the period September 3 to 5, 1966, added forty-two inches to the level at Victoria Beach.

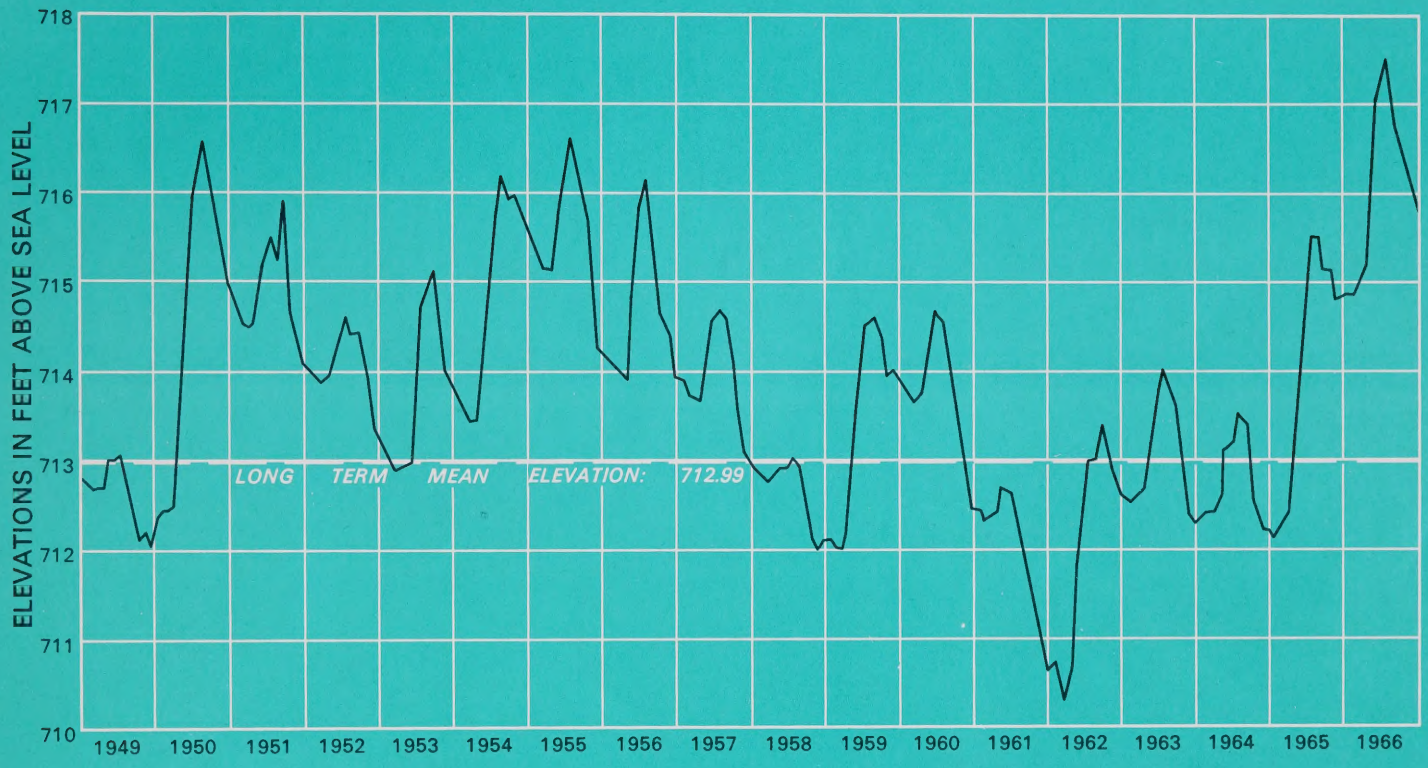
Man-made controls tend to moderate extremes of high and low water

There are man-made controls on several of the major river systems draining to Lake Winnipeg and the operation of these controls can effect the level of the lake. There is also a man-made control on the Nelson River, 230 miles below the outlet of Lake Winnipeg.

An important characteristic common to most control dams, whether or not they are designed specially for flood control, is their ability to store flood water during periods of high flow and release the stored water gradually when conditions downstream have returned to normal.

The outflow from Lake Manitoba is carried to Lake Winnipeg by way of the Fairford River. A dam on the Fairford River controls the level of Lake Manitoba. To attempt to use the Fairford Dam for flood control purposes by limiting the inflow to Lake Winnipeg would simply transfer the flood conditions to Lake Manitoba. Under conditions of high flow, therefore, the Fairford Dam is operated in such a way as to preserve flow conditions as closely to the natural state as possible; in 1966, operation of the dam resulted in a rise in the peak level of Lake Winnipeg of less than one-half inch.

On the other hand, water storage facilities on Lake of the Woods and Lac



Long-term hydrograph compares the high water level of 1966 with the levels of previous years.

Seul in the Winnipeg River system reduced the level of Lake Winnipeg by about seven inches and storage on the Saskatchewan River reduced the level by a further two inches. Water stored and diverted for irrigation in the South Saskatchewan River Basin also tended to moderate the level.

Water from Lake St. Joseph normally flows to James Bay via the Albany River. In years of low flow, however, water from Lake St. Joseph is diverted by way of a canal to the English River and thence to the Winnipeg River to increase the amount of flow available for the generation of hydro-electric power. The effect of diverting the water in periods of low flow is to raise the level of Lake Winnipeg by two or three inches. In periods of high flow, the diversion does not operate — it was in fact shut off in November 1965 and had no appreciable effect on the 1966 high water level.

Combining the effects of the works of man on Lake Winnipeg in 1966, the net result, therefore, was lowering of the peak level by about eight inches.

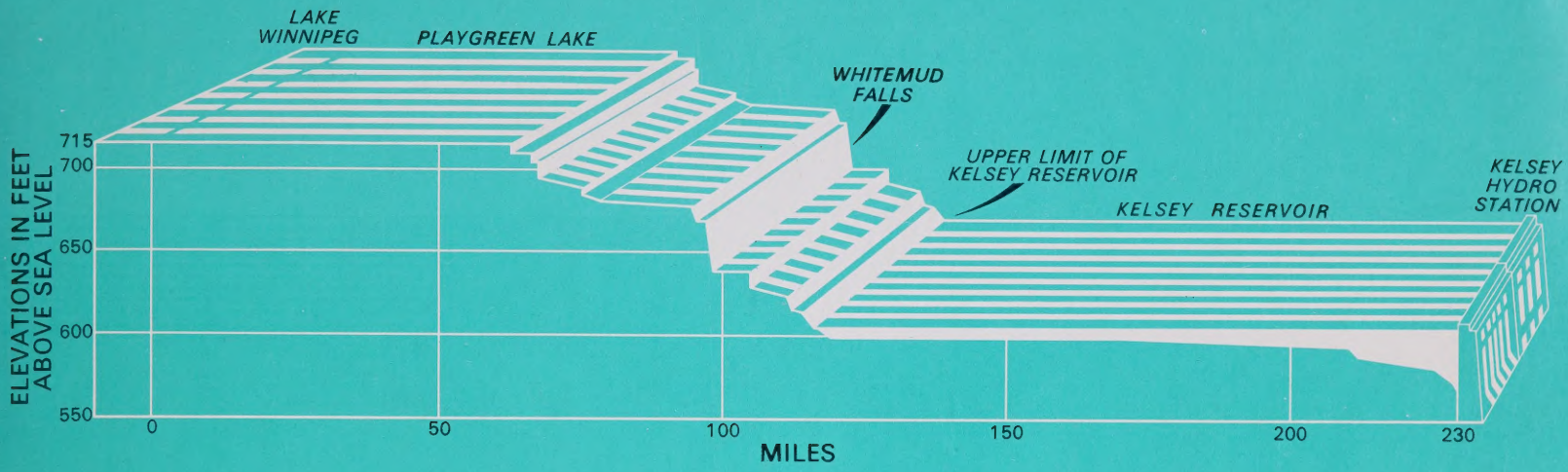
It should be noted here, however, that all the man-made controls which brought about this lowering of the water level are on river systems *upstream* from Lake Winnipeg. What was the effect on Lake Winnipeg of the man-made control at the Kelsey hydro-electric station on the Nelson River, 230 miles *downstream* from the lake?

The Kelsey Dam creates a storage reservoir which ponds the water of the Nelson River to an elevation of 605 feet above sea level for a distance of about 110 miles above the dam. But the upstream limit of this reservoir is about 120 miles *below* Lake Winnipeg, and between the elevation of Lake Winnipeg (713 feet) and the level of the Kelsey reservoir (605 feet) there is a difference of 108 feet. It is obviously impossible for the Kelsey Dam to affect the level of Lake Winnipeg.

Historical records reveal levels higher even than those of 1966

In summary, the water levels of Lake Winnipeg in any particular year are governed by a number of natural factors working together in complex and not easily predictable patterns. Variations in one or more of these factors or in the combination of factors may lead to extremely low water levels which bring their own particular problems, or to extremely high water levels even more severe than those of 1966. In 1901 and 1902, for example, the level was between one and a half and two feet higher than the 1966 peak and historical accounts point to an even higher level in 1879 and 1880. *The extremely high levels of 1901-02 and 1879-80 occurred prior to the existence of any major man-made control works in the drainage basin of Lake Winnipeg.*

In 1966, the net effect of artificial controls operating on river systems feeding Lake Winnipeg was to *reduce* the peak level below what it would have been under natural conditions. The Kelsey Dam, 120 miles below Lake Winnipeg, had no effect whatsoever.



NELSON RIVER

Inland Waters Branch,
Department of Energy, Mines and Resources,
Ottawa, Canada.

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